

FINAL REPORT  
APRIL 1997

REPORT NO. 96-62-1

MODULAR ARTILLERY CHARGE  
SYSTEM (MACS) PA161E1  
CONTAINER PALLET  
MIL-STD-1660 TESTS

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)  The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SIOAC-DEV), was tasked by U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct MIL-STD-1660 tests on a Modular Artillery Charge System (MACS) PA161E1 container pallet. This report contains the procedures and test results from MIL-STD-1660, Design Criteria for Ammunition Unit Loads, tests conducted. The MACS PA161E1 container successfully passed MIL-STD-1660 tests.					
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22a. NAME OF RESPONSIBLE INDIVIDUAL JEROME H. KROHN			22b. TELEPHONE (Include Area Code) 815-273-8929		22c. OFFICE SYMBOL SIOAC-DEV

U.S. ARMY DEFENSE AMMUNITION CENTER  
VALIDATION ENGINEERING DIVISION  
SAVANNA, IL 61074-9639

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MODULAR ARTILLERY CHARGE SYSTEM (MACS) PA161E1 CONTAINER PALLET  
MIL-STD-1660 TESTS

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## PART 1

### INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SIOAC-DEV), was tasked by U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct MIL-STD-1660 tests on a Modular Artillery Charge System (MACS) PA161E1 container pallet.

B. AUTHORITY. This test was conducted IAW mission responsibilities delegated by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, Illinois.

C. OBJECTIVE. The objective of these tests was to determine whether the MACS PA161E1 container pallet met MIL-STD-1660 requirements.

D. CONCLUSION. The MACS PA161E1 container pallet met MIL-STD-1660, Design Criteria for Ammunition Unit Loads, requirements.

## PART 2

15 - 19 AUGUST 1996

### ATTENDEES

Ejike J. Ajalla  
Mechanical Engineer  
DSN 585-8434  
815-273-8434

Director  
U.S. Army Defense Ammunition Center  
ATTN: SIOAC-DEV  
3700 Army Depot Road  
Savanna, IL 61074-9639

Bradley J. Hass  
Mechanical Engineer  
DSN 585-8336  
815-273-8336

Director  
U.S. Army Defense Ammunition Center  
ATTN: SIOAC-DEV  
3700 Army Depot Road  
Savanna, IL 61074-9639

Sanjeev Khanna  
Mechanical Engineer  
DSN 585-8083  
815-273-8083

Director  
U.S. Army Defense Ammunition Center  
ATTN: SIOAC-DES  
3700 Army Depot Road  
Savanna, IL 61074-9639

## PART 3

### TEST PROCEDURES

The test procedures outlined in this section were extracted from MIL-STD-1660, Design Criteria for Ammunition Unit Loads, 8 April 1977. This standard identifies nine steps that a unitized load must undergo if it is to be considered acceptable. The four tests that were conducted on the test pallets are summarized below.

A. STACKING TEST. The unit load was loaded to simulate a stack of identical unit loads stacked 16 feet high, for a period of one hour. This stacking load was simulated by subjecting the unit load to a compression weight equal to an equivalent 16-foot stacking height. The compression load was calculated in the following manner. The unit load weight was divided by the unit load height in inches and multiplied by 192. The resulting number was the equivalent compressive force of a 16-foot-high load.

B. REPETITIVE SHOCK TEST. The repetitive shock test was conducted IAW Method 5019, Federal Standard 101. The test procedure is as follows: The test specimen was placed on, but not fastened to, the platform. With the specimen in one position, the platform was vibrated at 1/2-inch amplitude (1-inch double amplitude) starting at a frequency of approximately 3 cycles per second. The frequency was steadily increased until the package left the platform. The resonant frequency was achieved when a 1/16-inch-thick feeler gage momentarily slid freely between every point on the specimen in contact with the platform at some instance during the cycle or a platform acceleration achieved 1 +/- 0.1 Gs. Midway into the testing period, the specimen was rotated 90 degrees and the test continued for the duration. Unless failure occurred, the total time of vibration was two hours if the specimen was tested in one position and three hours for more than one position.

C. **EDGEWISE ROTATIONAL DROP TEST.** This test was conducted using the procedures of Method 5008, Federal Standard 101. The procedure for the edgewise rotational drop test is as follows: The specimen was placed on its skids with one end of the pallet supported on a beam 4-1/2 inches high. The height of the beam was increased if necessary to ensure that there was no support for the skids between the ends of the pallet when dropping took place, but was not high enough to cause the pallet to slide on the supports when the dropped end was raised for the drops. The unsupported end of the pallet was then raised and allowed to fall freely to the concrete, pavement, or similar underlying surface from a prescribed height. Unless otherwise specified, the height of drop for level A protection conforms to the following tabulation:

GROSS WEIGHT (WITHIN RANGE LIMITS) (Pounds)	DIMENSIONS OF ANY EDGE, HEIGHT OR WIDTH (WITHIN RANGE LIMITS) (Inches)	HEIGHT OF DROPS ON EDGES	
		Level A (Inches)	Level B (Inches)
150 - 250	60 - 66	36	27
250 - 400	66 - 72	32	24
400 - 600	72 - 80	28	21
600 - 1000	80 - 95	24	18
1000 - 1500	95 - 114	20	16
1500 - 2000	114 - 144	17	14
2000 - 3000	Above 145 - No limit	15	12
Above - 3000		12	9

D. **INCLINE-IMPACT TEST.** This test was conducted by using the procedure of Method 5023, Incline-Impact Test of Federal Standard 101. The procedure for the incline-impact test is as follows: The specimen was placed on the carriage with the surface or edge which is to be



impacted projecting at least 2 inches beyond the front end of the carriage. The carriage was brought to a predetermined position on the incline and released. If it is desired to concentrate the impact on any particular position on the container, a 4- by 4-inch timber was attached to the bumper in the desired position before the test. No part of the timber was struck by the carriage. The position of the container on the carriage and the sequence in which surfaces and edges are subjected to impacts was at the option of the testing activity and depends upon the objective of the tests. This test is to determine satisfactory requirements for a container or pack, and, unless otherwise specified, the specimen was subjected to one impact on each surface that has each dimension less than 9.5 feet. Unless otherwise specified, the velocity at time of impact was 7 feet per second.

## PART 4

### TEST EQUIPMENT

#### A. Pallet (Test Sample).

- |                            |                    |
|----------------------------|--------------------|
| 1. Size:                   | 31.5- by 46.5-inch |
| 2. Pallet Load:            | PA161E1 containers |
| 3. Quantity of Containers: | 36                 |
| 4. Weight Loaded:          | 1,740 pounds       |
| 5. Unit Load Height:       | 52 inches          |

#### B. Compression Tester.

- |                       |                      |
|-----------------------|----------------------|
| 1. Manufacturer:      | Ormond Manufacturing |
| 2. Platform:          | 60- by 60-inch       |
| 3. Compression Limit: | 50,000 pounds        |
| 4. Tension Limit:     | 50,000 pounds        |

#### C. Transportation Simulator.

- |                  |                    |
|------------------|--------------------|
| 1. Manufacturer: | Gaynes Laboratory  |
| 2. Capacity:     | 6,000-pounds       |
| 3. Displacement: | 1/2-inch amplitude |
| 4. Speed:        | 50 to 400 rpm      |
| 5. Platform:     | 5- by 8-foot       |

#### D. Inclined Plane.

- |                  |                    |
|------------------|--------------------|
| 1. Manufacturer: | Conbur Incline     |
| 2. Type:         | Impact Tester      |
| 3. Grade:        | 10 percent incline |
| 4. Length:       | 12-foot            |

## PART 5

### TEST RESULTS

TEST OBSERVATIONS: Each pallet was loaded with 36 PA161E1 containers IAW DAC drawing 19-48-4231/50. Each container was filled with approximately 34 pounds of iron granules, creating a total 1,740-pound unitized load.

A. STACKING TEST. The test sample was initially loaded to 7,000 pounds compression. After 1 hour, the compression was released. No physical damage to the test sample was noticed.

B. REPETITIVE SHOCK TEST. The duration of the test was 90 minutes for each orientation of the test sample. In order to achieve a clearance between the test sample and the transportation simulator bed, the equipment was operated at 165 rpm for the longitudinal orientation and 166 rpm for the lateral orientation. No physical damage was noticed at the end of this test.

C. EDGEWISE ROTATIONAL DROP TEST. Each side of the pallet was placed on a beam displacing it 4-1/2 inches above the floor. The opposite end of the test pallet was raised to a height of 17 inches, then dropped. This process was repeated in a clockwise direction until all four sides of the pallet had been tested. There was no physical damage noticed at the end of this test.

D. INCLINE-IMPACT TEST. The incline-plane was set to allow the pallet to travel 8 feet prior to impacting a stationary wall. The pallet was rotated clockwise after each impact, until all four sides had been tested. No physical damage was noticed at the end of this test.

E. END OF TEST INSPECTION. During final inspection, there was no physical damage noticed on the test sample.

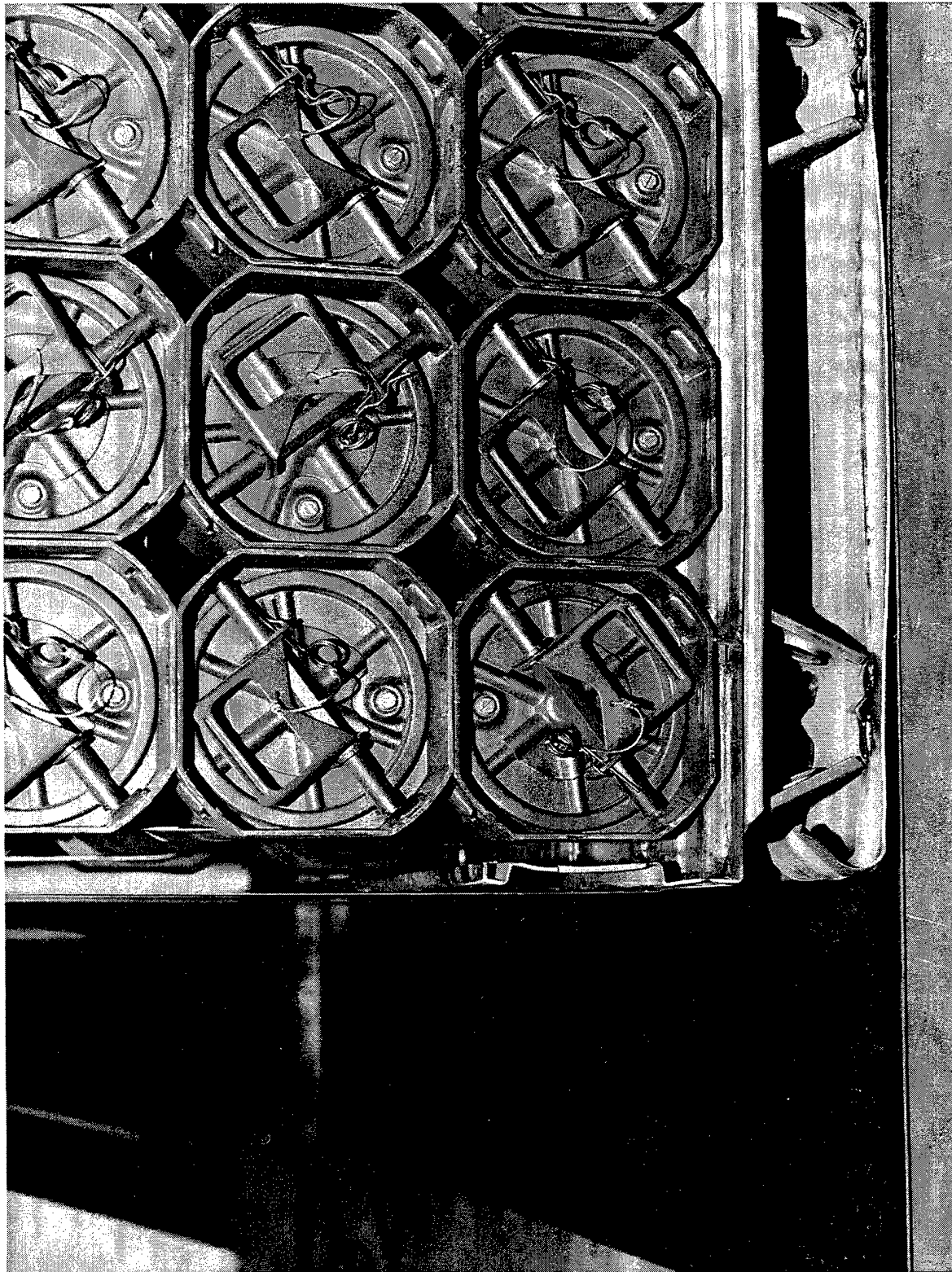
**PART 6**

**PHOTOGRAPHS**



U.S. ARMY DEFENSE AMMUNITION CENTER AND  
SCHOOL - SAVANNA, IL

A0317-SCN-96-173-4413. This photo shows the configuration of the palletized unit load.



U.S. ARMY DEFENSE AMMUNITION CENTER -  
SAVANNA, IL

AO317-SCN-96-173-4414. This photo shows a bottom view of the pallet unitized load following completion of MIL-STD-1660 tests.

**PART 7**

**DRAWING**

# APPENDIX 50

## UNITIZATION PROCEDURES FOR AMMUNITION AND COMPONENTS PACKED IN CYLINDRICAL METAL ON 4-WAY ENTRY METAL PALLETS

MODULAR ARTILLERY CHARGE SYSTEM (MACS),  
XM231, PACKED 4 PER PA161E1 CYLINDRICAL  
METAL CONTAINER, UNITIZED 36 PER 46-1/2"  
X 31-3/8" PALLET; APPROX CONTAINER SIZE  
31-3/8" L X 7-1/2" W X 7-1/2" H

NOTICE: THIS APPENDIX CANNOT STAND ALONE BUT MUST BE USED IN CONJUNCTION WITH  
THE BASIC UNITIZATION PROCEDURES DRAWING 19-48-4231-20PM1006.

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U.S. ARMY DEFENSE AMMUNITION CENTER

DRAFTSMAN

BETTY J. KUNDERT

ENGINEER

SANDRA M. SCHULTZ

SUPPLY ENGINEERING  
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FEBRUARY 1997

CLASS

DIVISION

DRAWING

FILE

19

48

4231/  
50

20PM.  
1006

DO NOT SCALE



PALLET UNIT DATA				
ITEMS INCLUDED		HAZARD CLASS AND DIVISION *		APPROX WEIGHT LBS
NSN	DODIC	DD CLASS	COMP GROUP	
1320-UNAS	---	-----	-	1,476

\* HAZARD CLASSIFICATION DATA CONTAINED IN THE ABOVE CHART IS FOR GUIDANCE AND INFORMATIONAL PURPOSES ONLY. VERIFICATION OF THE SPECIFIED DATA SHOULD BE MADE BY CONSULTING THE MOST RECENT JOINT HAZARD CLASSIFICATION SYSTEM LISTING OR OTHER APPROVED LISTING(S).

UNITIZING STRAP, 1-1/4" X .035"  
OR .031" X 16'-8" LONG STEEL  
STRAPPING (3 REOD).

TOP LIFT ASSEMBLY (1 REOD).  
SEE GENERAL NOTE "G" AT RIGHT.

SEAL FOR 1-1/4" STRAPPING  
(3 REOD, 1 PER STRAP).  
CRIMP EACH SEAL WITH  
TWO PAIR OF NOTCHES.

31-3/8"

46-1/2"

52-1/2"

SEAL FOR 3/4" STRAPPING  
(4 REOD, 1 PER STRAP).  
CRIMP EACH SEAL WITH TWO  
PAIR OF NOTCHES.

PALLET ADAPTER (1 REOD).  
SEE GENERAL NOTE "G"  
AT RIGHT.

46-1/2" X 31-3/8"  
PALLET. SEE  
GENERAL NOTE "G"  
AT RIGHT.

BUNDLING STRAP, 3/4" X .035" OR .031"  
X 11'-3" LONG STEEL STRAPPING (4 REOD).  
SEE GENERAL NOTE "C" AT RIGHT.

#### PALLET UNIT

SEE GENERAL NOTE "B" AT RIGHT.

36 CONTAINERS OF MACS (4 PER CNTR) AT 34 LBS	-----	1,224 LBS (APPROX)
DUNNAGE	-----	157 LBS
PALLET	-----	95 LBS
<hr/>		
TOTAL WEIGHT	-----	1,476 LBS (APPROX)
CUBE	-----	44.3 CU FT (APPROX)

#### BILL OF MATERIAL

METAL PALLET, 46-1/2" X 31-3/8"	--	1 REOD	--	95 LBS
PALLET ADAPTER	-----	1 REOD	--	70 LBS
TOP LIFT ASSEMBLY	-----	1 REOD	--	75 LBS
STEEL STRAPPING, 3/4"	-----	45.00'	REOD	-- 4.02 LBS
STEEL STRAPPING, 1-1/4"	-----	50.00'	REOD	-- 7.58 LBS
SEAL FOR 3/4" STRAPPING	-----	4 REOD	--	NIL
SEAL FOR 1-1/4" STRAPPING	-----	3 REOD	--	NIL

#### GENERAL NOTES

- THIS APPENDIX CANNOT STAND ALONE BUT MUST BE USED IN CONJUNCTION WITH THE BASIC UNITIZATION PROCEDURES DRAWING 19-48-4231-20PM1006. TO PRODUCE AN APPROVED UNIT LOAD, ALL PERTINENT PROCEDURES, SPECIFICATIONS AND CRITERIA SET FORTH WITHIN THE BASIC DRAWING WILL APPLY TO THE PROCEDURES DELINEATED IN THIS APPENDIX. ANY EXCEPTIONS TO THE BASIC PROCEDURES ARE SPECIFIED IN THIS APPENDIX.
- DIMENSIONS, CUBE AND WEIGHT OF A PALLET UNIT WILL VARY SLIGHTLY DEPENDING UPON THE ACTUAL DIMENSIONS OF THE BOXES AND THE WEIGHT OF THE SPECIFIC ITEM BEING UNITIZED.
- BUNDLING STRAPS MUST BE TENSIONED AND SEALED PRIOR TO THE APPLICATION OF THE UNITIZING STRAPS. INSTALL BUNDLING STRAPS AS CLOSE TO THE OUTER CONTAINER RINGS AS POSSIBLE, TO AVOID DAMAGE TO THE CONTAINERS. CAUTION: STRAPS MUST NOT BE ALLOWED TO OVERLAP.
- ALTHOUGH THE CONTAINERS DEPICTED IN THE UNIT LOAD AT LEFT ARE CONSTRUCTED WITH INTERLOCKING DEVICES, THE INTERLOCKS WILL NOT FUNCTION PROPERLY UNLESS THE CONTAINERS ARE POSITIONED SO THAT THE "PINS" OF THE INTERLOCKS ARE FACING UPWARD. THIS ORIENTATION WILL AID IN THE PREVENTING OF CONTAINER MOVEMENT, BOTH Laterally AND LONGITUDINALLY, DURING SHIPMENT OF THE UNIT LOAD.
- THE FOLLOWING AMC DRAWINGS ARE APPLICABLE FOR OUTLOADING AND STORAGE OF THE ITEMS COVERED BY THIS APPENDIX.
 

CARLOADING	-----	19-48-4242/SO-SPM1004
TRUCKLOADING	-----	19-48-4243/SO-11PM1004
STORAGE	-----	19-48-4250/SO-1-2-3-4-14-22PM1005
END OPENING ISO CONTAINER	-----	19-48-4245/SO-15PM1009
MILVAN	-----	19-48-4244/SO-15PM1008
SIDE OPENING ISO CONTAINER	-----	19-48-4272/SO-15PM1016
- IF ITEMS COVERED HEREIN ARE UNITIZED PRIOR TO ISSUANCE OF THIS APPENDIX, THE CONTAINERS NEED NOT BE REUNITIZED SOLELY TO CONFORM TO THIS APPENDIX.
- FOR DETAILS OF PALLET AND PALLET ADAPTERS, SEE AMCCOM DRAWING ACV00300, MIL-A-70788 AND MIL-P-70786.
- THE UNITIZATION PROCEDURES DEPICTED HEREIN MAY ALSO BE USED FOR UNITIZING MACS WHEN IDENTIFIED BY DIFFERENT NATIONAL STOCK NUMBERS (NSN) THAN WHAT IS SHOWN ON PAGE 2, PROVIDED THE CONTAINER DOES NOT VARY FROM WHAT IS DELINEATED HEREIN. THE EXPLOSIVE CLASSIFICATION OF OTHER ITEMS MAY BE DIFFERENT THAN WHAT IS SHOWN.
- EMPTY OR REJECT PA161E1 CONTAINERS WILL BE USED AS FILLER CONTAINERS AS NECESSARY. FILLER CONTAINERS MUST BE INSTALLED IN THE MIDDLE OF THE TOP LAYER(S) OF CONTAINERS. IF SIX FULL CONTAINERS ARE TO BE OMITTED, ONE FULL LAYER OF CONTAINERS WILL BE OMITTED. WHEN (EMPTY) FILLER CONTAINERS ARE USED IN PLACE OF OMITTED CONTAINERS TO COMPLETELY FILL OUT A LAYER ON A PALLET, THEY WILL BE MARKED AS SPECIFIED IN MIL-STD-129-1.
- WHEN TWO OR MORE LAYERS ARE OMITTED, THE BUNDLING STRAP REQUIREMENT WILL CHANGE. A FOUR LAYER UNIT WILL HAVE THE TWO BUNDLING STRAPS OMITTED THAT WERE AROUND THE THIRD, FOURTH AND FIFTH LAYERS. THE REMAINING BUNDLING STRAPS WILL SURROUND THE SECOND THROUGH FOURTH LAYERS. A UNIT WITH THREE OR LESS LAYERS DOES NOT REQUIRE BUNDLING STRAPS.
- FOR DETAILS OF PA161E1 CONTAINER SEE ARDEC DRAWING 12972583.

